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Theory of Magnetoresistance in Correlated Electron Systems: Modified Kohler Rule in High-T_c Superconductors

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In many correlated electron systems, the magnetoresistance (MR), $\Delta\rho/\rho$, shows various anomalous non-Fermi liquid behaviors. In high-T_c cuprates, for example, it is approximately proportional to T^{-4} in a wide range of temperatures, which means the strong violation of the Kohler's rule. Interestingly, so called 'modified Kohler's rule', $\Delta\rho/\rho \propto (R_H/\rho)^2$, is observed in general, where R_H is the Hall coefficient. To study the MR beyond the relaxation time approximation (RTA), we derived the general expression for the MR which is 'exact' of order τ^2 [1]. In the next stage, we study the MR in high-T_c cuprates from the standpoint of the Fermi liquid. Based on the obtained formula, we calculate the MR in terms of the fluctuation-exchange (FLEX) approximation, by including all the vertex corrections required by the Ward identity (i.e., the conserving approximation). [2]. Then, we find the approximate relation $\Delta\rho/\rho \propto \xi_{AF}^4 \cdot \rho^{-2}$ due to the vertex corrections for the current (ξ_{AF} being the antiferromagnetic correlation length) in the presence of the AF fluctuations. By taking account of the relation $R_H \propto \xi_{AF}^2$ derived in Ref.[3], we can naturally explain the modified Kohler's rule, which cannot be reproduced by the RTA. In conclusion, our study gives the consistent understanding for the $seemingly$ non-Fermi liquid behaviors of ρ, R_H and $\Delta\rho/\rho$ on the equal footing in terms of nearly AF Fermi liquid.

[1] H. Kontani, cond-mat/0011328. [2] H. Kontani, cond-mat/0011327.
[3] H. Kontani, K. Kanki and K. Ueda: Phys. Rev. B **59** (1999) 14723.